Scintillator Tiles and Test Beam Plans

Tungsten Timing

T3B

TestBeam

Calice Collaboration Meeting – Casablanca 2010

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Excellence Cluster
Universe

Calorimeter for ILC

Outline

- Aims of T3B (Tungsten Timing Test Beam)
- Scintillator Tile Development
- The Test Beam Setup(s)
- First Muon Data from CERN Installation
- Summary

AIMS OF T3B

Recap: Aims of the T3B Experiment

- Information about the time structure of hadronic showers in Tungsten is crucial for the development of a CLIC HCAL
  - The observed Time Structure depends on the active medium (sensitivity to neutrons) → Need scintillators to evaluate an analog HCAL
  - Directly coupled scintillator tiles, read out with fast digitizers can be used for detailed measurements of the time structure of the shower

  - Construct one timing layer = one strip of tiles
  - Run together with the CALICE AHCAL at CERN PS in November
  - Match T3B Events to CALICE Events to obtain the shower start

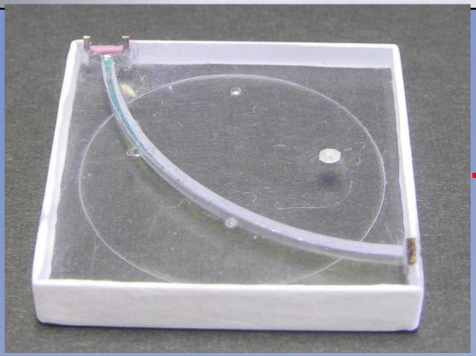
Obtain first information on the timing of the lateral and longitudinal shower profile

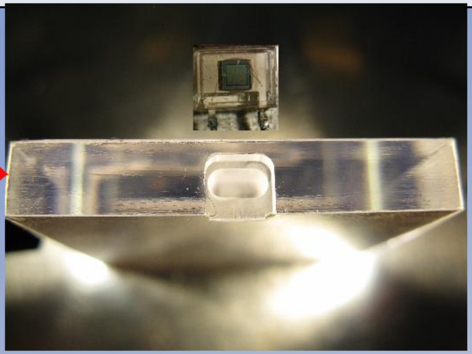
SCINTILLATOR TILE DEVELOPMENT

The Core: Scintillator Tile Design

CALICE

- Mephi Pulsar
- Embed WLS



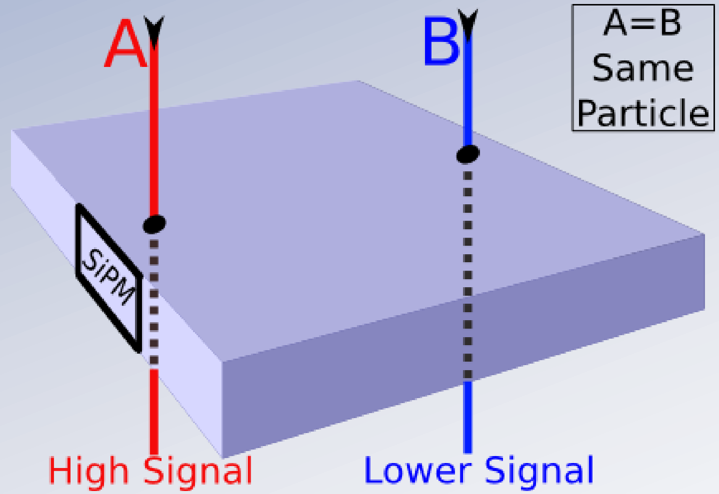


T3B

- MPPC
- Direct coupling

Direct Coupling

- Avoid cost and time consuming procedure of WLS embedding and SiPM alignment
  → Couple photomultiplier directly to the scintillator tile
  → Possible through development of blue sensitive SiPMs
  → Needs: Modification of tile geometry to obtain uniform response to penetrating particles



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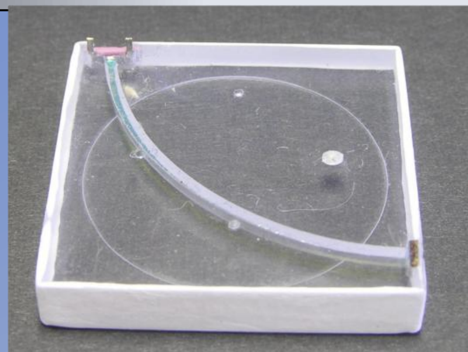

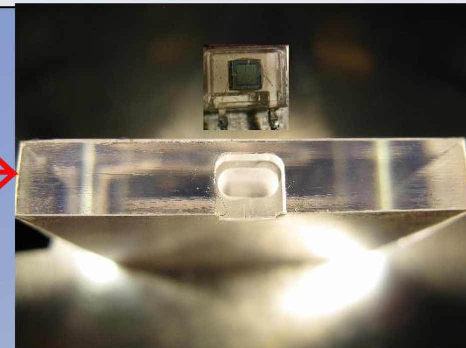

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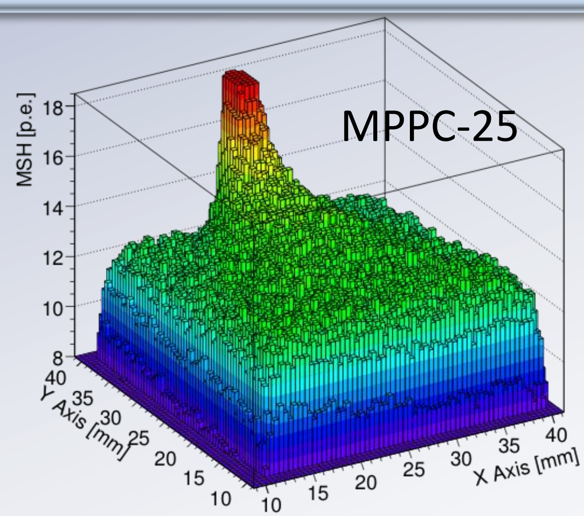
Result from the Test Bench:

-Irradiation with Sr90 (β -Decay)

-Lateral Scan over Tile



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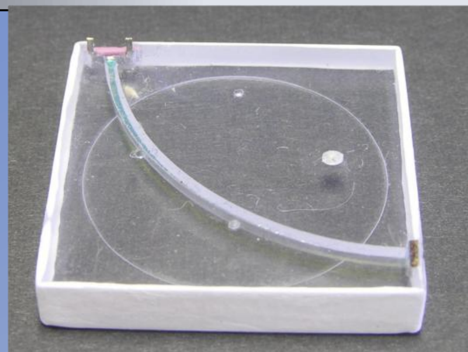

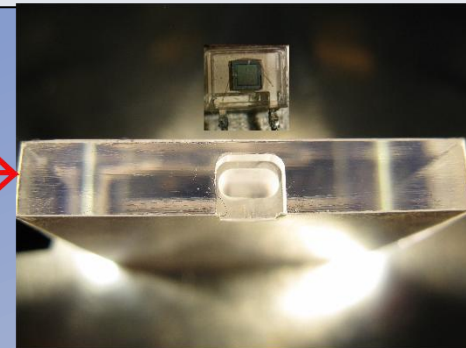

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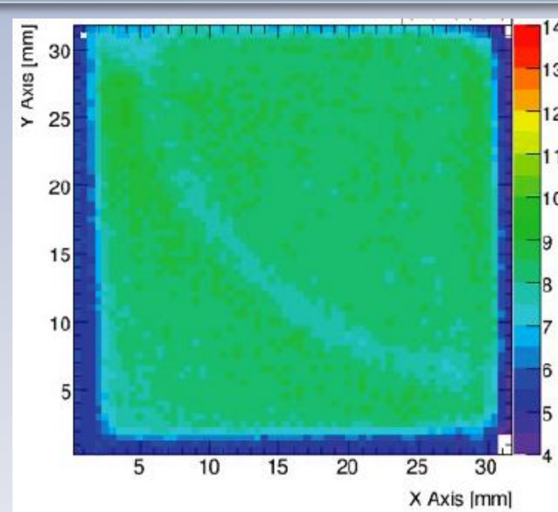
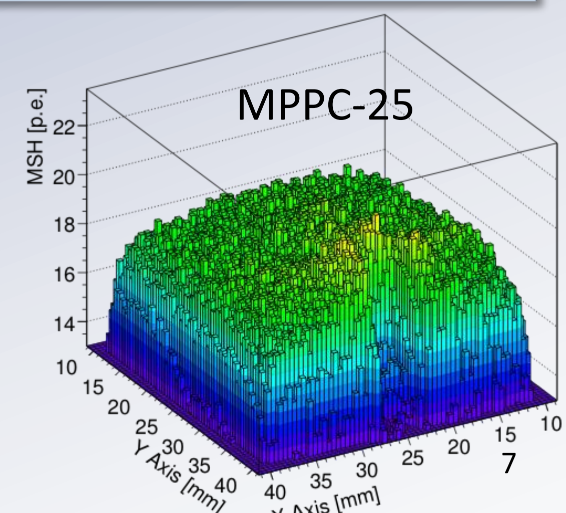
WLS Measurement:
Reduced signal amplitude. Sensitivity of MPPC not matched to fiber emission.





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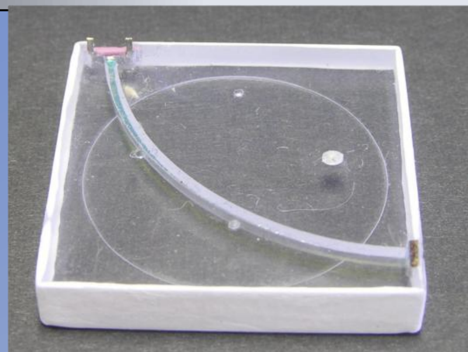
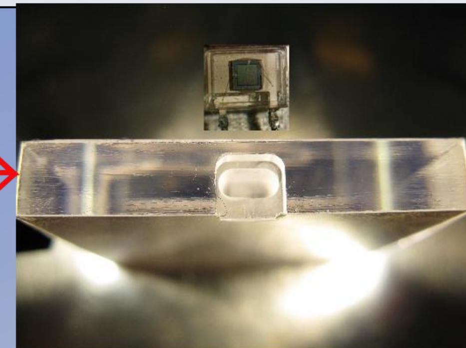




T3B

- MPPC-50C
- Direct coupling

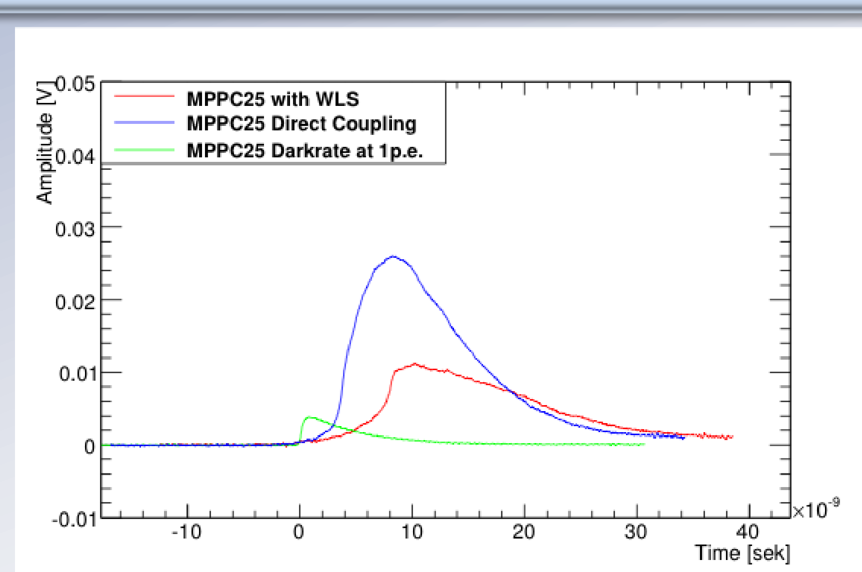
Direct Coupling

- WLS adds additional delay to the photon signal (excitation process)
- Improve the timing of the intrinsic signal through direct coupling

Result from the Test Bench:

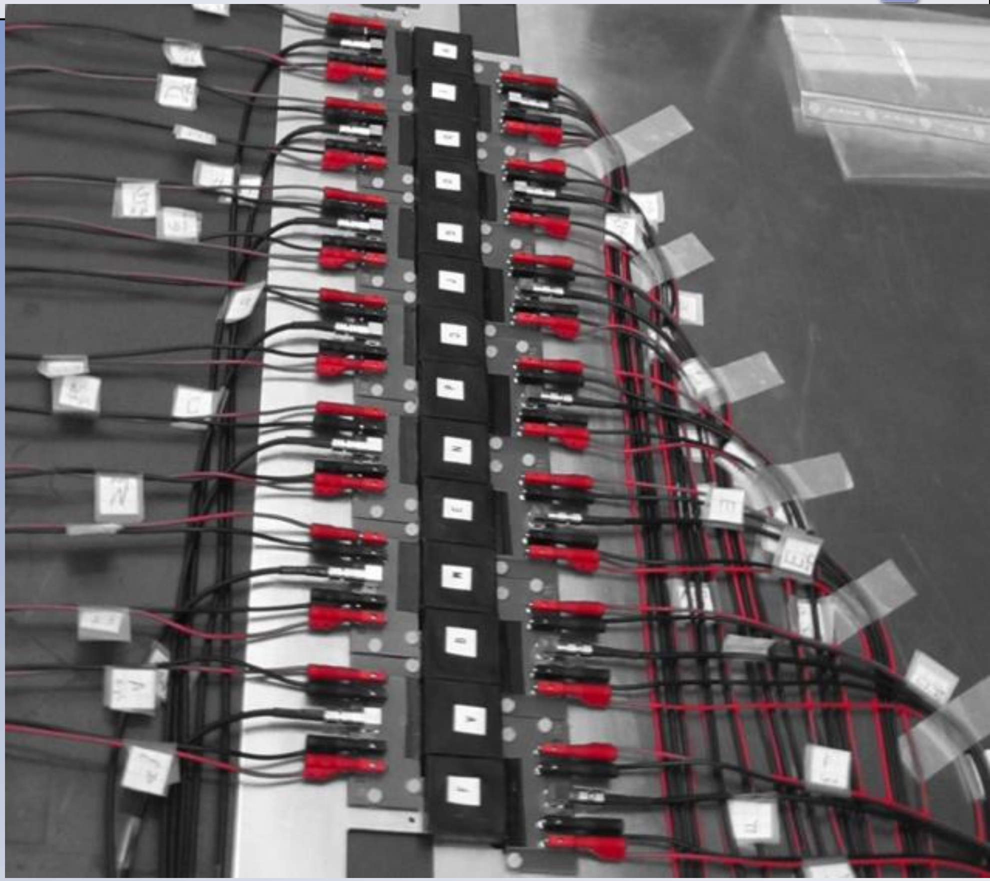
- Irradiation with Sr90 (β-Decay)
- Record and average the signal of 500 penetrating electrons
- Signal faster and faster peaking (!)

→ Important to determine the ToFH accurately



THE TEST BEAM SETUP(S)

The Test Beam Setup of T3B



- One layer = row of 14 scintillator tiles
- Tile size: 3 x 3 x 0.5 cm^3
- SiPM: Hamamatsu MPPC-50C
- Readout: 4 x PicoScope 6403
  - Fast Digitizer (1.25GSa/s on 4CH)
  - Deep memory (1GSa)
  - Fast data capturing (up to 1MHz)

T3B Test Installation at CERN

Power distribution:
HV for SiPMs (~73V), LV for preamps
(More sophisticated installation foreseen)

Special setup: Muon Telescope, not used in November

Power supplies: SiPM HV, Preamp LV in addition: DVM, not mandatory for November

PicoScopes: The heart of the DAQ

DAQ Computer, Screen not mandatory in November

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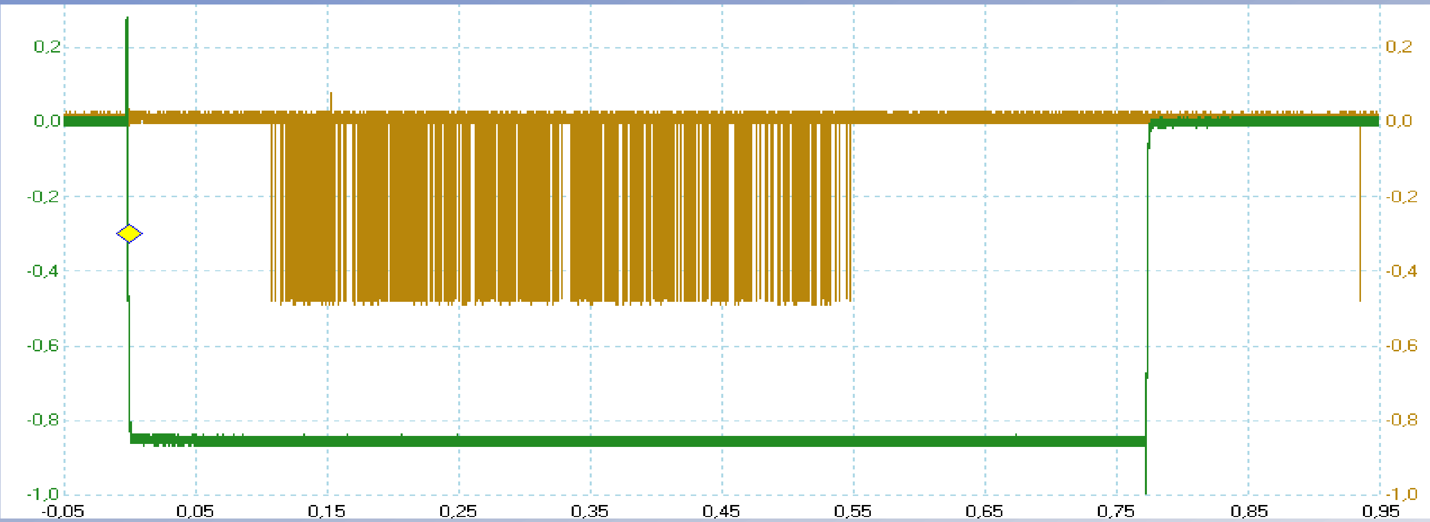
Trigger Synchronisation

- T3B Timing Layer is positioned behind 30 Tungsten and AHCAL Layers
- Crucial: Correlate events in T3B with events in the W Stack
  →Determine the position of the timing layer relative to the shower start



Enclosing Spill signal:
→ ~780ms
→ PS2203 triggers T3B readout and data transfer

Triggers from CALICE backplane:
→ ~70ns
→ Used as external trigger for T3B data capturing

- Match events by ensuring T3B records all CALICE triggers (spill by spill)
  (CALICE trigger rate: ~1-2kHz←→maximum T3B trigger rate: ~1MHz)
- Identify CALICE timeout or calibration (fake) triggers:
  - T3B Data: Record beam trigger signal on one T3B input channel to directly
  - CALICE Data: Time stamp information of each CALICE event in final LCIO

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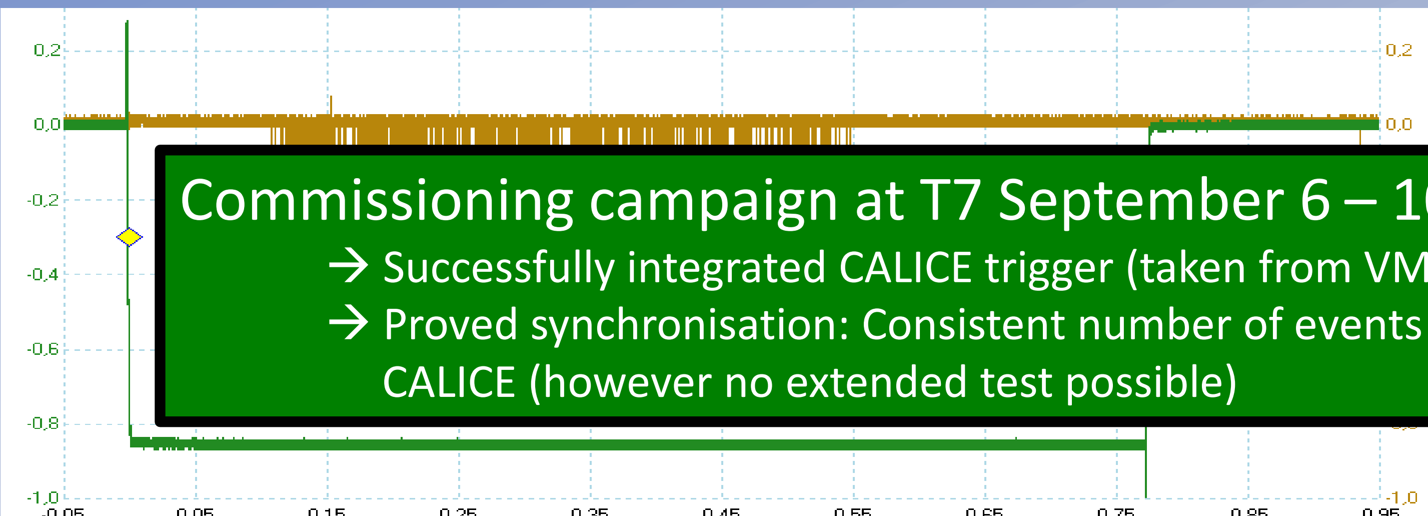

Enclosing Spill signal:
→ ~780ms
→ PS2203 triggers T3B
ransfer

CE

→ Used as external trigger for T3B data capturing

Commissioning campaign at T7 September 6 – 10:

→ Successfully integrated CALICE trigger (taken from VME Backplane)

→ Proved synchronisation: Consistent number of events for T3B and CALICE (however no extended test possible)

- Match events by ensuring T3B records all CALICE triggers (spill by spill)
  (CALICE trigger rate: ~1-2kHz ←→ maximum T3B trigger rate: ~1MHz)
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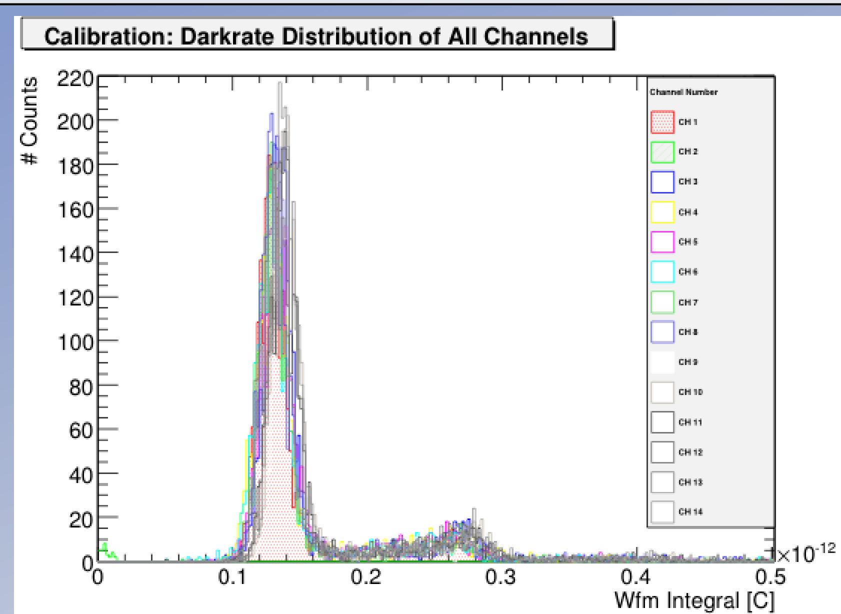
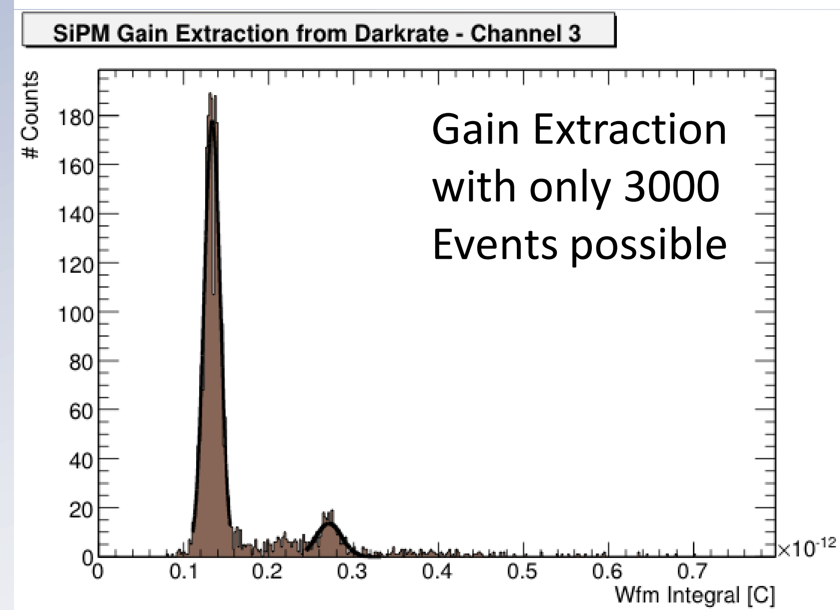
T3B Calibration

SiPM Gain Monitoring:

• Test Beam: Intermediate Noise Run Mode
→ Take ~250 Darkrate Events per Channel after each spill processing
→ ~3000 Events (≈ 6-12 Spills ≈ 4.5-9 minutes) suffice for SiPM Gain extraction





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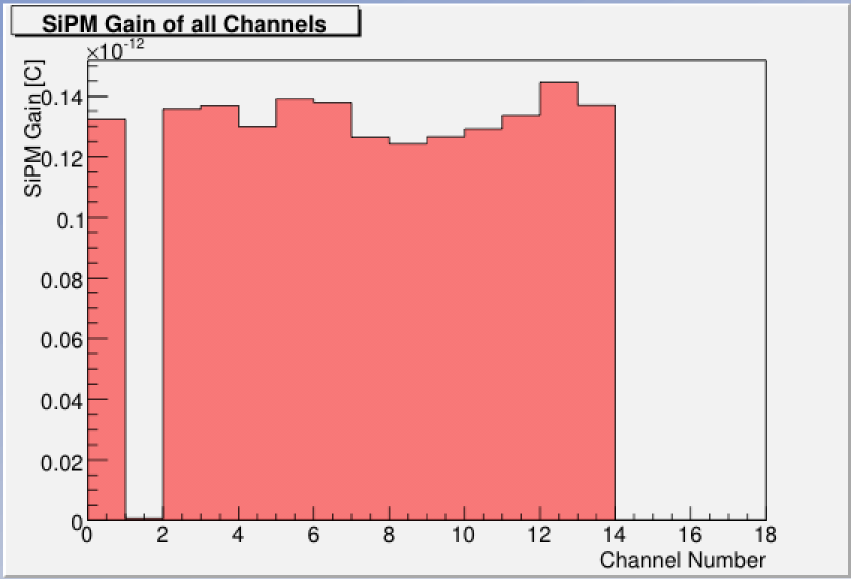
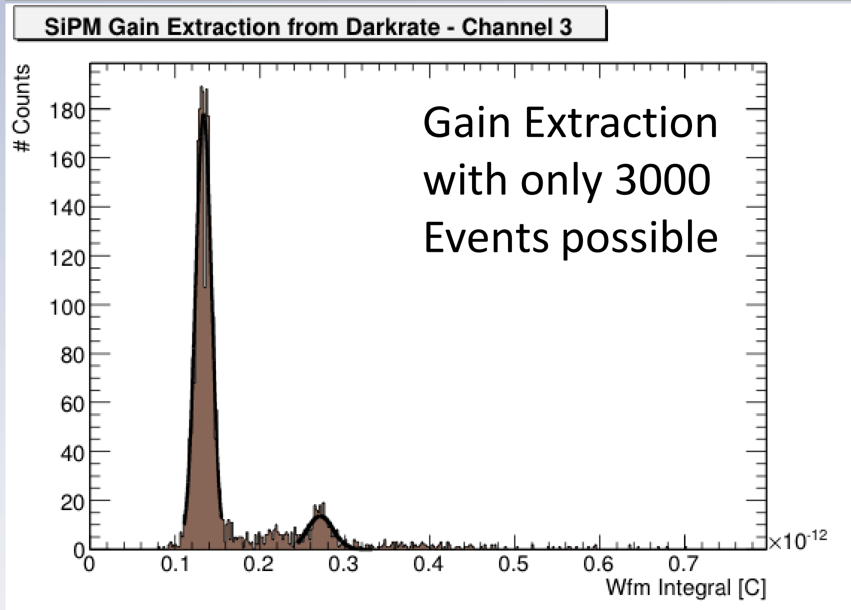
• Test Bench: Gain-Amplitude Correlation
→ Measure #p.e./MIP with Sr90
(note: e- ≠ MIP but correlation identical)
→ Steer through different Bias Voltages and Temperatures
→ Obtain: $A(T,U_{Bias}) = c(T,U_{Bias}) \bullet G(T,U_{Bias})$
→ Check consistency for different cells

Perform a Signal Correction using SiPM Gain Data





FIRST DATA FROM CERN INSTALLATION

First Results: Intrinsic T3B Timing

- Test Arrangement A: 1 PicoScope

  - External Trigger Input of PS: CALICE Trigger

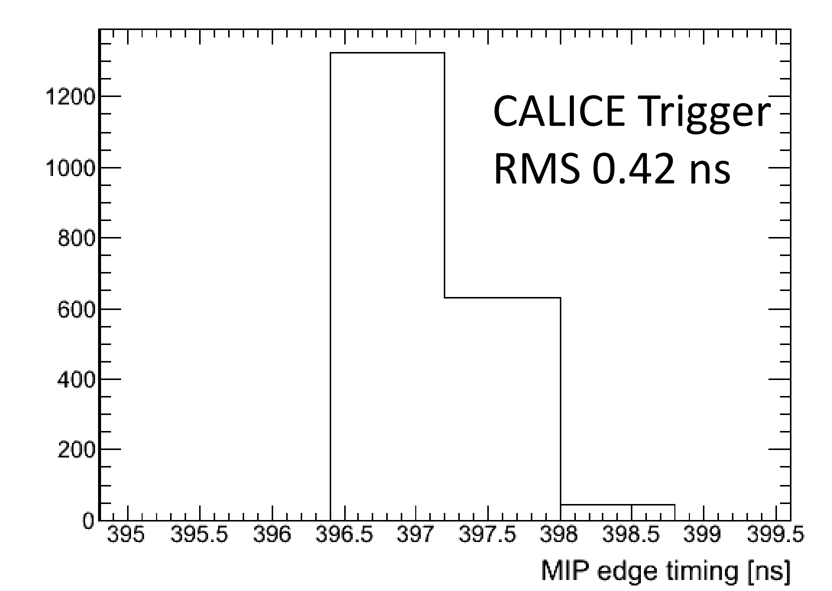
  - 1 Input Channel of PS: same CALICE Trigger

→ Histogram the timing of rising signal edge

→ RMS of edge timing distribution ≈ 400ps

Intrinsic time jitter of T3B DAQ ≈ 400ps

(Improvement through PicoScope trigger time offset possible)

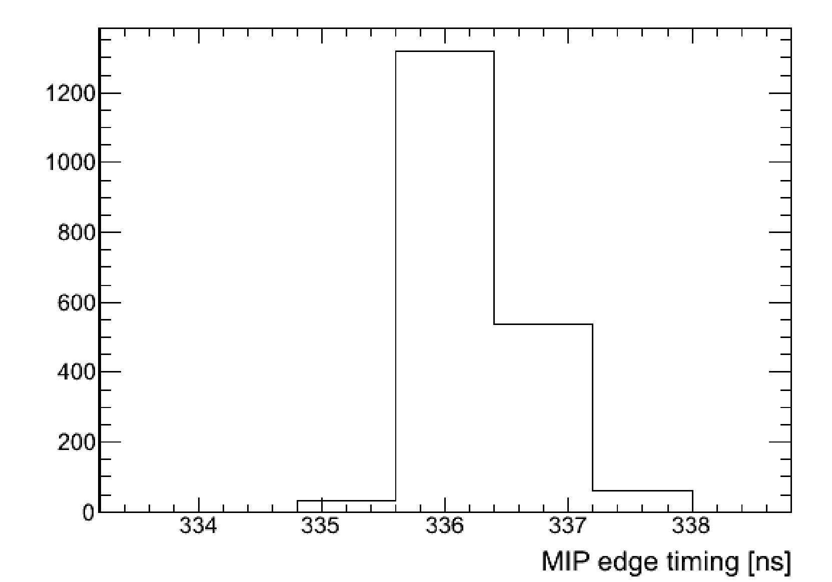


- Test Arrangement B: 1 PicoScope

  - External Trigger Input of PS: CALICE Trigger

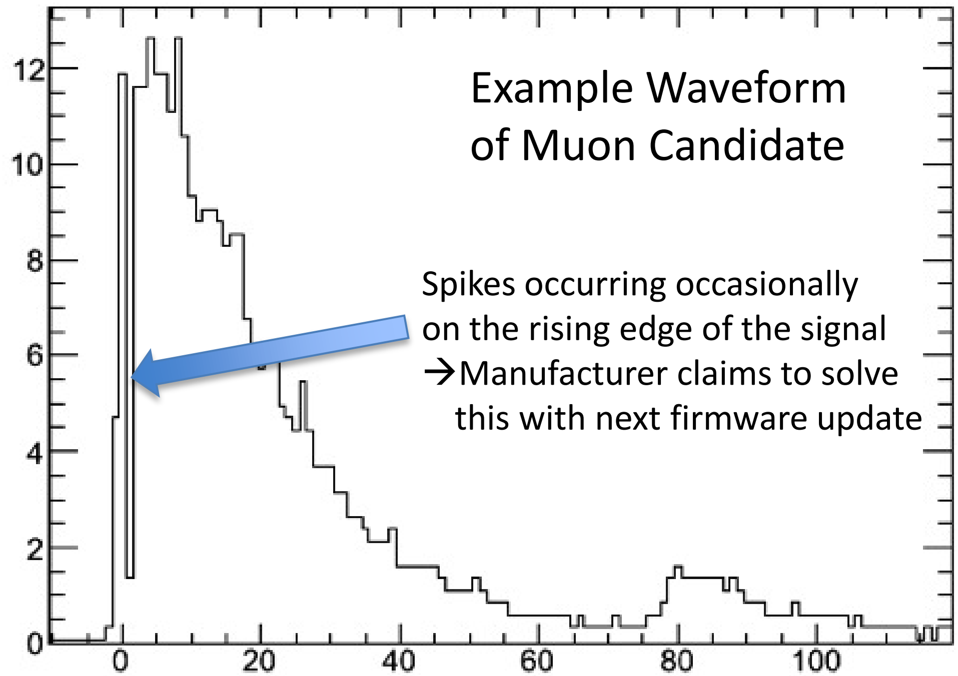
  - 1 Input Channel of PS: Beam Scintillator Trigger

No additional jitter introduced by CALICE DAQ



First Results: The Muon Telescope

- Main goal of test: Study timing and efficiency of scintillators
  - Efficiency studies ongoing...



Muon Candidates:

→ Perform pedestal substraction

→ select Muon signals by a threshold of 4p.e. above the baseline

First Results: The Muon Telescope

- Main goal of test: Study timing and efficiency of scintillators
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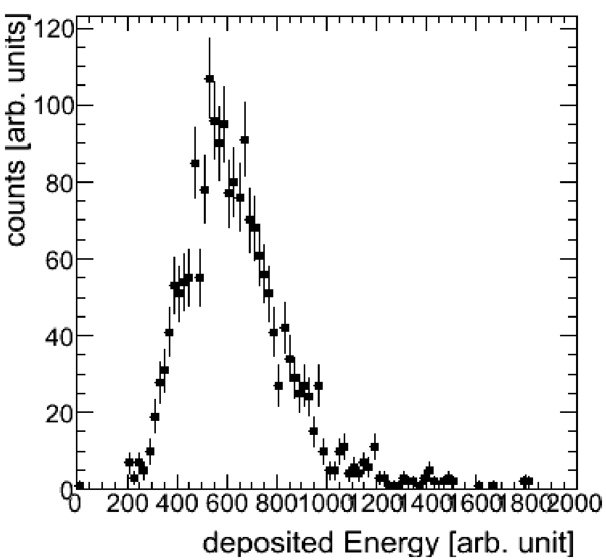
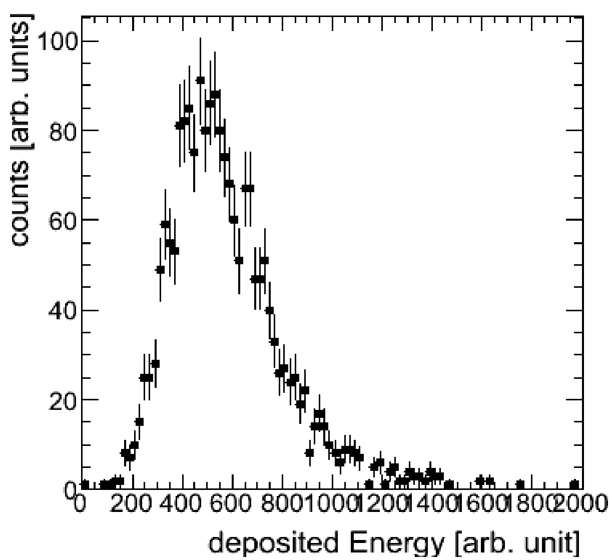
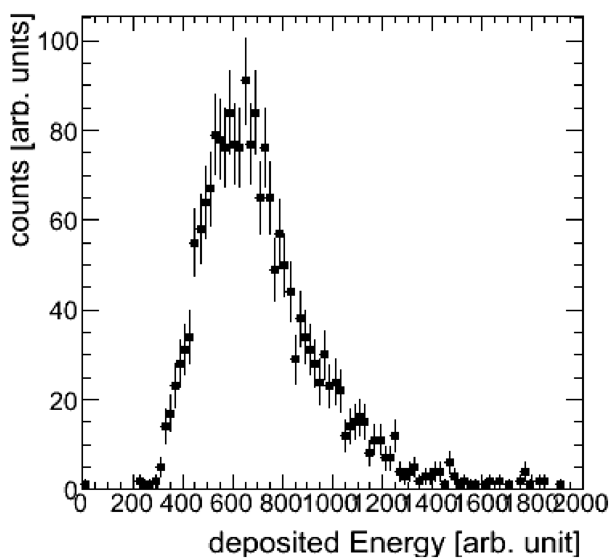
Define time window around triggered sample:

→Histogram the waveform integral of tile 1,2,3

→MPV typically at 26p.e. (as expected from bench tests)







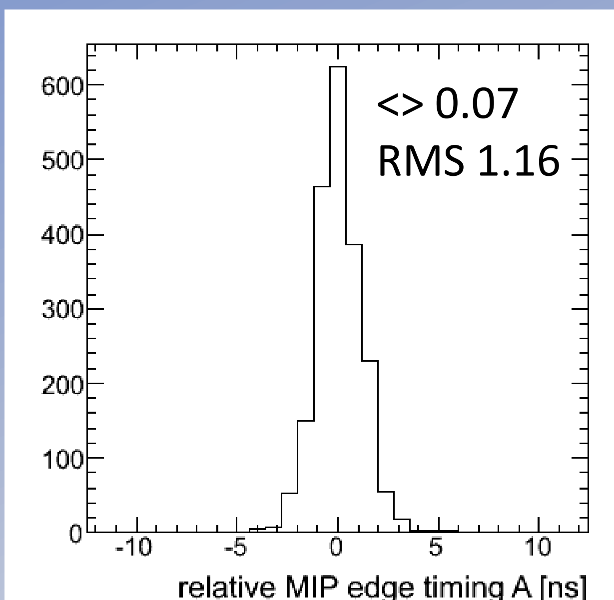
First Results: MIP Signal Timing with Muon Telescope

- Test Arrangement C: 1 PicoScope → Standalone Run

  - Input Channel A,B,C of PS: Scintillator Tile 1 (front), 2 (middle), 3 (back) connected

  - Trigger condition: Signal coincidence between front and back → study middle

→ Edge Timing given by sample above threshold (more sophisticated methods possible)



Typical RMS Width: $\Delta T_{tot,MIP} \approx 1.1 - 1.2\,ns$

Investigate relative MIP Edge timing:

$$T_{rel} = T_B - T_A$$

Time resolution:

$$\Delta T_{tot,MIP} = \Delta T_{MIP}(TileB) \oplus \Delta T_{MIP}(TileA) = \Delta T_{MIP} \bullet \sqrt{2}$$

→ T3B time resolution for MIPs: ~ 800 ps

(simple threshold method, further improvement by respecting intrinsic resolution possible)

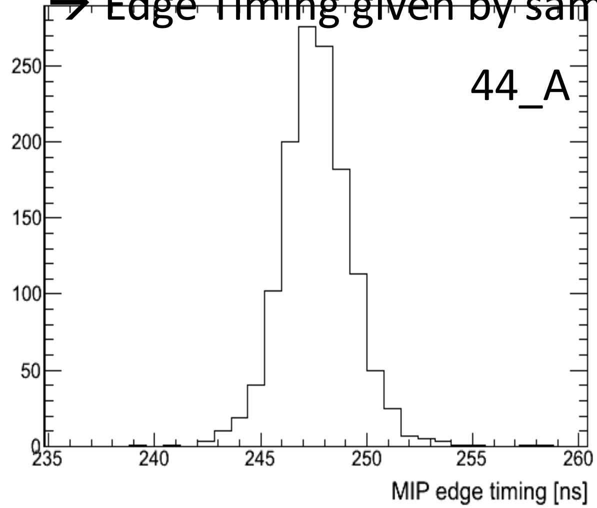
First Results: Timing Strip Data

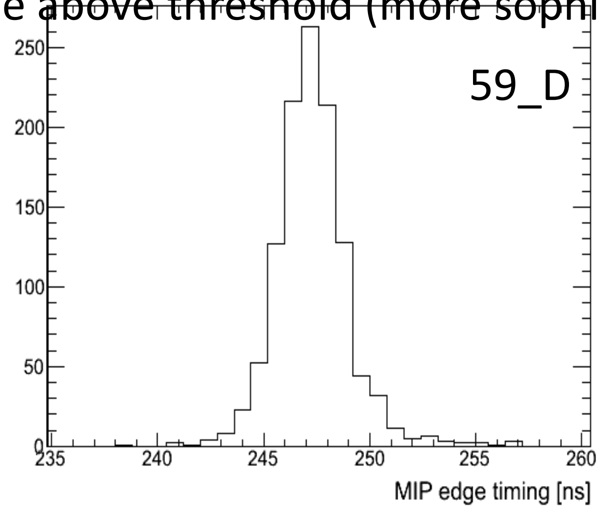
- Test Arrangement D: Full Test Beam Setup - 4 PicoScopes

  - External Trigger Input of PS: CALICE Trigger using large 50x80cm Muon Beam Scintillators

  - 14 Input Channels of PS: 14 Scintillator tiles of the T3B Timing Layer

→ Edge Timing given by sample above threshold (more sophisticated methods possible)





Typical RMS width:

~1.6 ns

Now modified Time resolution:

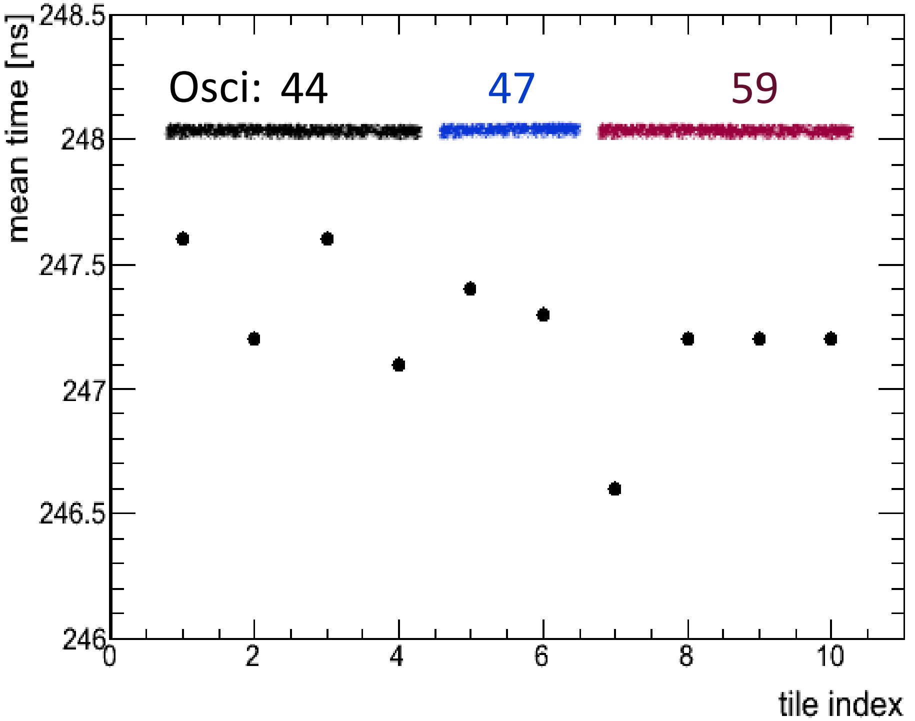
$$\Delta T_{tot} = \Delta T_{tot,MIP} \oplus \Delta T_{MuonTrigger}$$

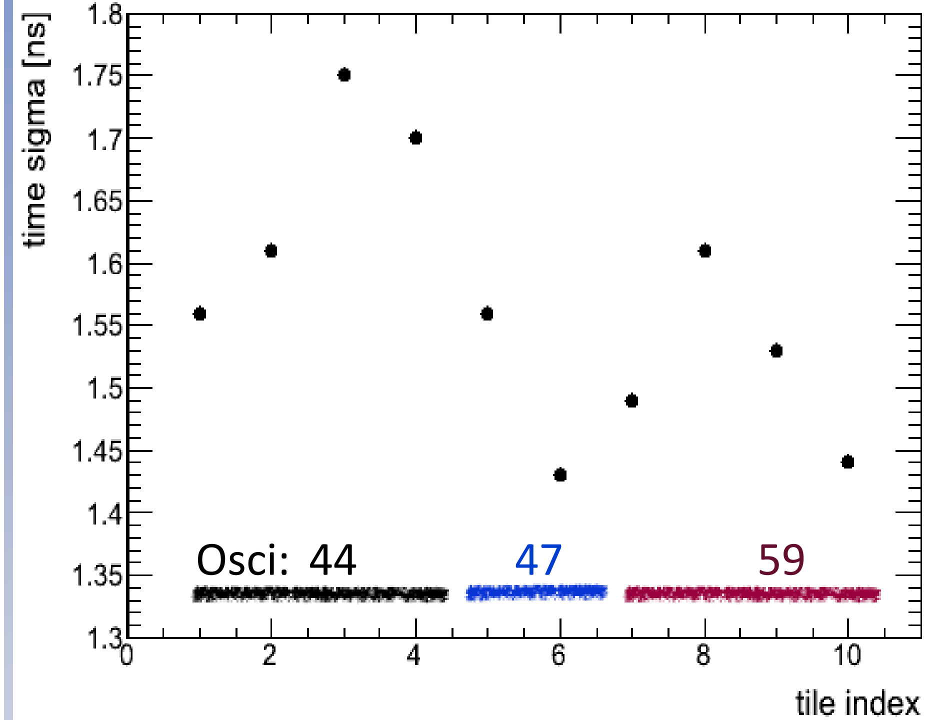
,where $\Delta T_{MIP} \approx 0.8\,ns$, $\Delta T_{tot} \approx 1.6\,ns$

→Large trigger adds ~ 1.3 ns spread (not used in hadron Test Beam)

(remember: All events are within 3 x 3 cm on the large trigger!)

Timing of Full T3B Setup





1 PicoScope used in parallel for Muon Telescope → only 10 channels available

Result: Stable behaviour on all channels: (1.6 ± 0.2)ns
(further improvement in analysis possible)

<u>SUMMARY</u>

Summary

- Valuable experience from T3B commissioning run
  - Integration with CALICE Trigger proven, synchronisation works
  - Hardware mostly working (one channel broken, might be a short due to packaging)
  - Some oscillations observed on two of the four oscilloscopes, investigating
  - Some Muons to look at to develop analysis tools, quantify system performance
- Open question:
  - Spill structure for November test beam?
    - T3B DAQ not optimized for two spills that follow quickly one after the other, need ~ 5s between spills at the moment
    - Challenging: Constantly changing spill structure...

Special Thanks to:

- Frank Simon and Lars Weuste, whose commitment at CERN Commissioning and at Data Analysis

- The CALICE AHCAL Group, whose permanent support

Make this experiment possible!